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THE CALCULATION OF ANISOTROPIC PROPERTIES ON THE BASE OF ENGINEERING STRUCTURES

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ABSTRACT

We consider the definition of the kernel function and the effect of a transversely isotropic half-space. Expressions are derived deflections and internal forces in an infinite base plate in accordance with their recesses in the mountain range, as well as the influence of anisotropy on the base distribution of deflections and internal forces.

Key words: Anisotropic properties, Engineering structures and kernel.

INTRODUCTION

Improved economic performance in construction is directly related to the use of more advanced designs, including a large place occupied by the deformable structure basis. These are the foundations and structures erected in areas with rugged. Cost bases and foundations of modern engineering structures in the piedmont areas of 15-20 percent of the value of all construction[1-3]. Along with the knowledge of the stress-strain state of the structures and foundations of buildings, it is extremely important to study the soil forming the base, the properties of which are included in the design parameters of load-bearing structures. It is particularly important to determine the strength of the subgrade shear and

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fracture pressure. The accuracy of the data will be improved if we consider the anisotropic deformation and strength properties of the subgrade, the orientation of the plane of isotropy with respect to the surface of the soil mass and the distribution of stresses in the ground bearing foundations of buildings on the anisotropic base[4-6].

Geometric nature and the degree of anisotropy of rocks depends on the mineralogical composition, structure, texture, but most of these features are related to the conditions of formation bedding, followed by metamorphism, and the advent of fracture[2,7,8].

Variety of properties of soil bases, depending not only on the conditions of their natural occurrence, but also on the stress-strain state, humidity, and temperature, etc., cannot be described adequately and in detail with the help of simple circuits. The problem arises of creating more complex models bases that do not contradict the basic positions of soil mechanics and structural mechanics. The question of a plausible scheme of the base, the analysis of the various competing models and the choice of an appropriate computational model of the base are very critical part of the design. Clarification of the elastic module of the base and to determine their parameters experimentally increase the reliability of research results. Development of more computerized calculation methods will reduce the development time of these structures and thus reduce the share of design work. All this leads to a more economical and, therefore, decreases the labor and materials for the construction of structures. To identify features of anisotropic basis is necessary to conduct experimental research (Fig. 1)[9,10].

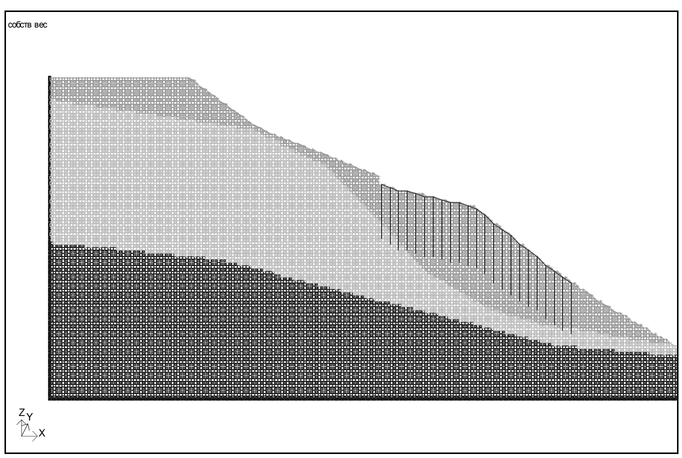

Fig. 1: General view of the design scheme of the slope - the ski base jumping in Almaty

In general, the rock mass has the property of elastic anisotropy, which is primarily a consequence of the manifestation of layering and fracturing rock strata. For the first time the feasibility of accounting elastic anisotropy of rocks contains S. G. Lehnitskim consider only the horizontal layering of the array of simulated transversely elastic body, the plane of isotropy coincides with the bedding plane layers[12].

Anisotropic model finely layered array ramp isotropy, first used by Erzhanovym et al.[5]

Experimental data on soil bases in the construction of the ski jump in Almaty showed that the investigated rock massif has trasversalno-isotropic properties: modulus of elasticity E2 along the bedding layers twice the elastic modulus E1 in the direction perpendicular to the plane of isotropy, i.e. $E_1 > E_2$, ($E_1 = 2E_2$). Therefore, to calculate the support structures springboard, was considered a model of subgrade, taking into account the anisotropic properties of the soil[11,12].

As it is well known, the properties of the base characterized by the influence function c (α,β), which the form depends on the model adopted base. For some reason kind of function (α,β) presented in the works of Korenev. Before proceeding to the study of the stress-strain state of structures and foundations of buildings, lying on a linearly deformable uniform basis, first consider an important auxiliary problem of the relationship between the vertical forces acting on the basis and foundation deflections[13,14].

We will consider the kernel, which can be represented graphically in the form of a surface of revolution, i.e., kernels of the form –

$$K\,(x-\xi, y-\eta) = K\left(\sqrt{(x-\xi)^2 + \mu\,(y-\eta)^2}\right) \qquad \ldots(1)$$

Where μ - is a constant

The corresponding model base may be of value in the anisotropy in the xy-plane, as well as in dealing with dynamic problems. For the design of structures and foundations of buildings on elastic anisotropic basis, it is necessary to determine the dependence of the vertical displacements of the ground surface from the action on the surface of the concentrated force.

As a model of anisotropic foundation is transversely-isotropic half-space having the following physical and mechanical properties: $E_z = E_1$ – modulus of longitudinal elasticity in the vertical direction; $E_r = E_2$ – modulus of longitudinal elasticity in the horizontal direction (in-plane isotropic); ν_1 – Poisson's ratio characterizing transverse contraction in the plane of the anisotropy in tension in the direction perpendicular to it; $\nu_2 = \nu$ – Poisson's ratio corresponding to the stretching in the plane anisotropy and characterizing the transverse compression in the plane; G, G2 – shear module, respectively, to the plane of isotropy and perpendicular to it. The modulus G2 is received the lowest for any ratio of the module of elasticity. In the presence of the specific values of the shear module determined experimentally for real soils may be included in the formulas obtained. Specifications and strain coefficients on Bekhterev can be expressed as follows:

$$a_{11} = \frac{1}{E_r}, a_{12} = -\frac{v}{E_r}, a_{33} = \frac{1}{E_z};$$

$$a_{13} = \frac{v_1}{E_z}, a_{44} = \frac{1}{G_R}, 2(a_{11} - a_{12}) = \frac{2(1+v)}{E_r} = \frac{1}{G_K} \quad \ldots(2)$$

Vertical movement of the direction of the x-axis under the action of axisymmetric forces expressed in terms of the stress function φ[12]:

$$w = \alpha\left(\frac{\partial^2\varphi}{\partial r^2} + \frac{1}{r}\frac{\partial\varphi}{\partial r} + \beta\frac{\partial^2\varphi}{\partial z^2}\right) \quad \ldots(3)$$

где $\alpha = \frac{1}{A_{44}}; \beta = \frac{A_{44}}{A_{11}};$ A_{ij} – elastic module;

$$A_{11} = \frac{a_{11}a_{33} - a_{13}}{(a_{11} - a_{12})\,m}; A_{44} = \frac{1}{a_{44}}; m = (a_{11} - a_{12})\,a_{13} - 2a_{13}^2$$

Function φ must satisfy the differential equation:

$$\nabla_1\nabla_2\varphi = 0 \quad \ldots(4)$$

Where $\Delta_i = \frac{\partial^2}{\partial r^2} + \frac{1}{r}\cdot\frac{\partial}{\partial r} + \frac{1}{s_i^2}\cdot\frac{\partial^2}{\partial z}$, (I = 1,2).

Function φ is defined as follows:

$$\varphi = \int_0^\infty \left(Ce^{-s_1\lambda z} + De^{-s_2\lambda z}\right) J_0(\lambda r)\, d\lambda \quad \ldots(5)$$

Where λ - parameter integration;

$S_{1,}$ S_2- roots of the characteristic equation:

$$s_1 = \frac{\sqrt{a+c+\sqrt{(a+c)^2-4d}}}{2d}; \quad s_2 = \frac{\sqrt{a+c-\sqrt{(a+c)^2-4d}}}{2d};$$

$$C = -\frac{\Psi(\lambda)}{\lambda^2}.\frac{(1-as_2^3\sqrt{d}}{(s_1-s_2)(ac-d)}; \quad D = -\frac{\Psi(\lambda)}{\lambda^2}.\frac{(1-as_1^3\sqrt{d}}{(s_1-s_2)(ac-d)};$$

$$a = -\frac{a_{13}(a_{11}-a_{12})}{a_{11}a_{33}-a_{13}^2}; \; c = -\frac{a_{13}(a_{11}-a_{12})+a_{11}a_{44}}{a_{11}a_{33}-a_{13}^2}; \; d = \frac{a_{13}^2-a_{12}^2}{a_{11}a_{33}-a_{13}^2}$$

Function $\psi(\lambda)$, included in the expressions for C and D, corresponding to a given load q and is determined by the Hankel Transform:

$$q(\lambda) = \int_0^\infty q(\xi)\xi.\, J_0(\lambda\xi)\, d\xi \qquad \ldots(6)$$

Substituting (5) into (4) and solving the equation we obtain the formula for finding the displacement:

$$w = \frac{P\alpha}{2\pi(s_1-s_2)}\left(\frac{\xi_1}{\sqrt{r^2+s_2^2z^2}} - \frac{\xi_2}{\sqrt{r^2+s_1^2z^2}}\right) \qquad \ldots(7)$$

Moving surface transversely isotropic half-space we obtain from (7) at z = 0:[15]

$$w_{z=0} = \frac{P\alpha(s_1+s_2)(a-\beta)\sqrt{d}}{2\pi(ac-d)\,r} \qquad \ldots(8)$$

Kernel for transversely isotropic elastic half-space will get by putting in (7) P = 1:

$$K(r) = \frac{\alpha(s_1+s_2)(a-\beta)\sqrt{d}}{2\pi(ac-d)\,r} \qquad \ldots(9)$$

Now, substituting (9) into the expression for the function c(λ), characterizing the model base, we obtain:

$$c(\lambda) = \frac{\alpha(s_1 + s_2)(a - \beta)\sqrt{d}}{(ac - d)} \cdot \frac{1}{\lambda} \qquad \ldots(10)$$

Denote

$$k_{TP} = \frac{(ac - d)}{\alpha(s_1 + s_2)(a - \beta)\sqrt{d}} \qquad \ldots(11)$$

Then
$$c(\lambda) = \frac{1}{k_{TP}\lambda} \qquad \ldots(12)$$

For the kernel transversely isotropic half-space ratio $\kappa_{\text{тр}}$ is –

$$k_{TP} = \frac{ac - d}{\alpha(s_1 + s_2) * (a - \beta)\sqrt{d}} = \frac{E_z}{2\overline{w}_{z=0}} \qquad \ldots(13)$$

The expression obtained kernel transversely isotropic half-space with the horizontal plane of isotropy differs from the corresponding core isotropic half-space ratio $\overline{w}_{z=0}$, which takes into account the anisotropy of the base according to the relationship $E_z/E_r = k_{\text{тр}}$, values ν_1 and ν_2. The analytical expression of deflections and internal forces in the base plate, given its penetration in the subsurface array can solve a number of problems in an analytical form, for infinite and finite for foundation slabs, using the methods-time work in the[16].

Calculation plates lying on the surface of the anisotropic base, i.e. at z = 0, are considered in[17,18]. Study the distribution patterns of movement within and on the boundary of a deformable half-space under the action of a force applied to the boundary plane, carried out by Zaletov and Hrapilova[19].

For example, consider the case of anisotropy $k_E = 5$. Figures 1-5 show the diagrams deflections; radial, tangential bending moments and shear forces in the endless base plate loaded by a concentrated force P = 1 for values

z = 0, 2, 3, 5, 10 and E_z = 50 MPa; M_r = 10 MPa.

The results show a significant influence of anisotropy on the base of the distribution of values of deflections and internal efforts to change the depth of the foundation plates. For example, the values of the deflection plates at z = 0 for the isotropic case is - w = 0.385, and when z = 10 for the anisotropic case, respectively - w = 0.118, i.e. value of the deflection is more than 3.3 times the value of the deflection plates on the basis of an isotropic with the same penetration. A similar pattern is observed for the internal forces[20,21].

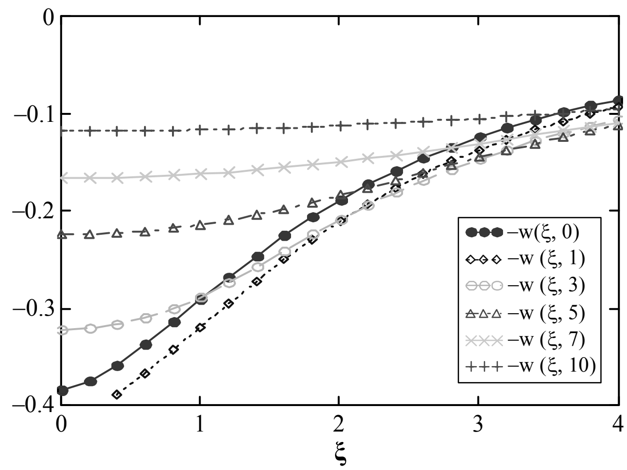

Fig. 2: The diagram of figure 1 in an endless deflection plate at k_E = 5 is loaded by a concentrated force P = 1 is given recess at z = 0, 2, 3, 5, 7, 10

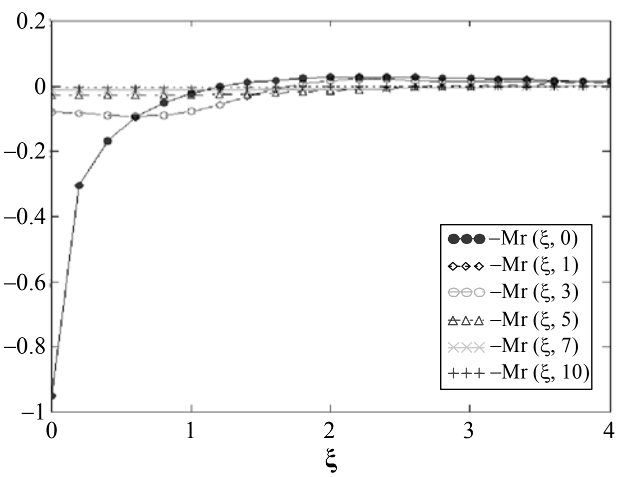

Fig. 3: Radial bending moments in an infinite plate with k_E = 5, loaded by a concentrated force P = 1 when the light of improved z = 0, 2, 3, 5, 7, 10

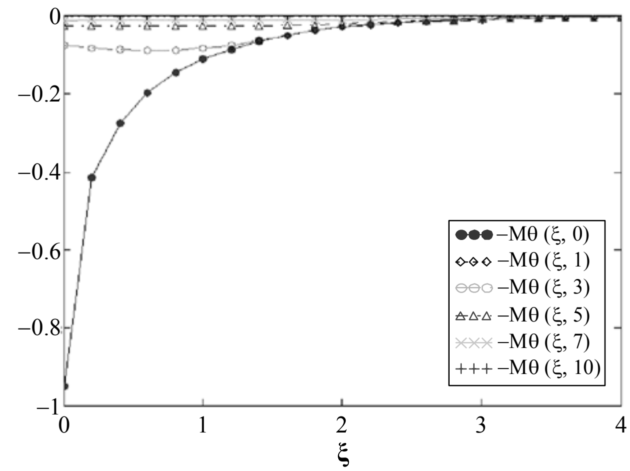

Fig. 4: The diagram of the tangential bends moments in an infinite plate with $k_E = 5$, loaded by a concentrated force P = 1 with the deepening at z = 0, 2, 3, 5, 7, 10

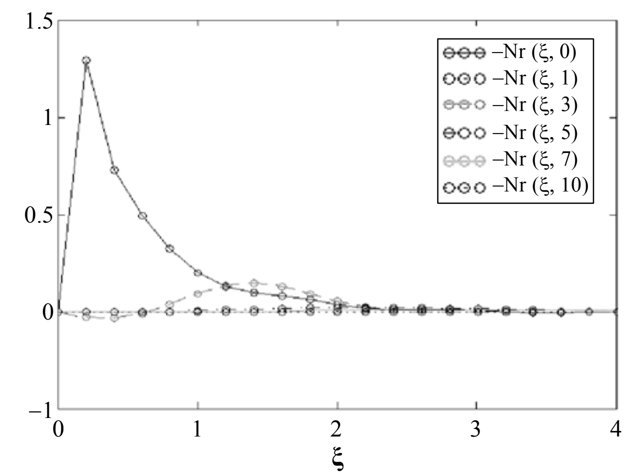

Fig. 5: The diagram of shear forces in an infinite plate with $k_E = 5$, loaded by a concentrated force P = 1 with the deepening at z = 0, 2, 3, 5, 7, 10

CONCLUSION

The results obtained in this paper can also be used as a criterion to assess the validity of the results obtained in the numerical studies. Based on these dependencies identified the stress-strain state of the soil, which is based on the foundations of the ski jump in Almaty.

REFERENCES

1. K. Terzaghi and R. Peck, Soil Mechanics in Enginering Practice, New Iork (1948).
2. Donald P. Coduto, Man-chu Ronald Yeung and William A. Kitch, 2nd Ed., Gtotechnical Engineering, Principles and Practices, USA: Pearson (2011) pp. 28-63.
3. E. B. Lopatin and O. R. Nazarevskiy, Assessment of Natural Living Conditions Naseleniya, Moscow, Nauka, S., S.61-122 (1972).
4. A. K. Bougrov and A. I. Golubev, Anisotropic Soils and Foundation Structures, St. Petersburg: Nedra, 245C (1993).
5. J. S. Erzhanov, Sh. M. Aytaliev and J. K. Massanov, Stability of Horizontal Mine Workings in an Obliquely Layered Array, Alma-Ata: Nauka (1971) p. 160.
6. I. N. Dyusembaev and E. T. Besimbaev, On the Calculation of the Springboard with the Anisotropic Properties of the Base, Mechanics and Construction of Transport Facilities, Proc. Scientific-Practical Conference, Conference Dedicated to the 75th Birthday of Aytalieva Sh. M., Almaty (2010).
7. N. A. Tsytovich, Soil Mechanics (Short Course), M.: High School, Tutorial for Building Schools, Ed. 4th Revised and Ext. (1983) p. 288.
8. K. Terzaghi, Theoretical Soil Mechanics, New Iork (1948).
9. L. I. Manvelov and E. S. Bartosiewicz, On the Choice of the Computational Model of the Elastic Foundation, Structural Mechanics and Payment Structures, No. 4, 14-18 (1967).
10. E. T. Besimbaev and S. K. Khamzin, Determination of the Design Parameters of a Mathematical Model of a Viscoplastic Deformation of Soils: Geotehnichesike Problems of Building, Architecture and Geoecology at the Turn of the Twenty-First Century, Sb.nauchn, Proceedings of the 1st Central Asian Geotechnical Symposium Astana (2000).
11. V. A. Hamsters, V. A. Pustagachev and E. T. Besimbaev, Researches of Properties of Soil at Underground Construction in the City of Almaty, Proceeding of Korea-Kazakhstan, Joint Geotechical. Incheon Green Environment Center S. (2012) pp. 165-167.
12. S. G. Lehnitsky, The Theory of Elasticity of an Anisotropic Body, Moscow: Nauka, 416s (1977).

13. B. G. Korenev, Issues of Analysis of Beams and Plates on Elastic Foundation, M. Gosstroyizdat (1954).

14. G. Y. Popov, The Contact Problem for Linearly Deformed Base, Kiev, Odessa High School (1982).

15. J. Boussinesq, Application Eles Potentiels a l'Etude l'Equilibre et du Mouvement des Solides Elastiques/Gauthier, Villars, Paris (1885) p. 721.

16. V. I. Travush, Bend Uninsulated Slab Lying on Linear-Deformable Foundation Generic, Studies in the Theory of Structures, M.: Stroiizdat, MY. XVII, C. 73-84 (1969).

17. O. J. Schechter, On the Influence of the Layer Thickness of Soil on the Stress Distribution in the Foundation Beam and Plite, M. Proceedings of NIS Deep Trust Works, 17s (1944).

18. M. I. Gorbunov-Possadov, T. A. Malikov and V. I. Solomin, Calculation of Constructive-tions on an Elastic Foundation, M: Stroiizdat, 678s (1984).

19. V. V. Zaletov and N. S. Hrapilova, Patterns of Distribution of Displacements in an Isotropic Half-Space Lying on an Elastic Foundation under the Action of a Concentrated Force, Works IAMR NAS, Donetsk, Tom 20 (2010) pp. 65-14.

20. Dyusembaev and E. T. Besimbaev, A Mathematical Model of the Interaction of the Elastic System Trampoline Anisotropic Basis, Mechanics and Construction of Transport Facilities, Works Mezhdunar.nauch-prakt.konferen. Dedicated to the 75th Anniversary of Academician Aytalieva Sh.M., Almaty (2010).

21. E. T. Besimbaev, V. A. Hamsters et al., Report on Development of Technology for Cutting the Soil on the Slopes of the Ski Jump, Almaty KazGASA, 88c (2009).

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